OAR:
The Basic Research Agency
of The United States Air Force

USAF ACADEMY

OFFICE OF SCIENTIFIC RESEARCH / A F CAMBRIDGE RESEARCH LABORATORIES / AERONAUTICAL RESEARCH LABORATORIES / EUROPEAN OFFICE, O A R

Vol. 1 : 4

23 APRIL 1962

SOLAR ECLIPSE EXPEDITION

Sacramento Peak Observatory, AFCRL

The solar chromosphere is an imperfectly understood phenomena. The chromosphere is so sketchy because it can be viewed in full detail for only about 10 minutes every hundred years. This view is permitted only during periods of total eclipse. The most recent eclipse occurred on 5 February 1962 in New Guinea. AFCRL sponsored an eclipse expedition to the island of Lae, New Guinea, under the direction of Dr. Richard Dunn of AFCRL's Sacramento Peak Observatory. A clear sky made possible a perfect view of the eclipse. The observations and recorded data will provide a better understanding of the energies of the sun that create the chromosphere and the sun's corona. The chromosphere is a dense layer of the solar atmosphere that lies in a 1000 to 10,000 mile band between the visible surface of the sun and the solar corona. The corona is a more tenuous segment of the solar atmosphere above the chromosphere. A more complete understanding of the chromosphere may tell us something of the physical process of the sun. We would like to know more about the transfer of energy from the sun itself to the chromosphere. The temperatures of the chromosphere greatly exceed those of the visible surface of the sun itself, some 10,000 degrees F., compared to temperatures of 50,000 to 100,000 degrees in the chromosphere. Of more immediate interest to AFCRL scientists is the intense ultraviolet radiation from the chromosphere that creates the earth's ionosphere. Solar flares originate in the dense gases of the chromosphere, and these can profoundly disturb the ionosphere, and thus disrupt communications and degrade radar performances. Artificial eclipses have been made for several years at AFCRL's Sacramento Peak Observatory by means of a telescope known as a coronagraph. Coronagraph takes advantage of the fact that the chromosphere emits very strong light at a wave length of 6563 Angstroms units. With a strong monochromatic filter, other wave lengths from the sun and from the corona can be blacked out. Thus we are able to see the chromosphere in stark detail. The difficulty is that the coronagraph excludes all light emissions of the chromosphere except emissions at 6563 Angstroms units. We are able to see the full spectrum of chromosphere emissions only during an actual eclipse.

TO OUR READERS

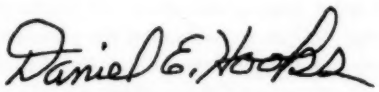
The continuing goal of the "OAR RESEARCH REVIEW" is an attempt to satisfy the information needs of both the scientist and the nonscientist decision maker, since we feel each is of importance.

It is inevitable that many decisions concerning basic research, from the budget that supports it to the manner in which it is fed into applied research and development activities, are made by people who are not scientists.

We believe that it is imperative that these people be informed about research in progress, and understand something of its potentialities. It is equally imperative that the scientist be kept up-to-date on research projects occurring within his areas of interest. Each time this publication prevents needless duplication of effort by informing a research scientist of new knowledge discovered, it will have achieved an important contribution to the conservation of the Free World's scientific resources.

Those of you among our readers who feel a need for further information about a topic covered in any issue are urged to contact the author or originating laboratory direct. Addresses for use on such occasions are shown on inside back cover of this issue.

Constructive criticism and suggestions for improvement will be most welcome, and should be directed to this headquarters, ATTN: RREI.



DANIEL E. HOOKS
Major General, USAF
Commander

INVESTIGATION OF MECHANISM OF ENERGY TRANSFER

The Sensitization of Biacetyl Fluorescence and Photo-Oxidation of Biacetyl in Fluid Solutions

JEAN T. DUBOIS, Chemistry Research Branch, ARL

Aside from the important contribution to fundamental knowledge, the Air Force interest in investigations of mechanisms of energy transfer lies in the almost limitless number of potential applications to a variety of practical phenomena such as memory devices, flame mechanisms and the measurement of temperatures in hot gases, the detection of nuclear radiation by scintillation, the protection against radiation dosage and the utilization of solar energy. Research of this nature was carried out at the Aeronautical Research Laboratory as part of a program on energy transfer, and its purpose was primarily to differentiate between certain possible mechanisms of electronic energy transfer in dilute solutions.

The transfer of electronic energy in fluid solutions may occur:

a. During bimolecular encounters of the electronically excited donor molecule with the unexcited acceptor molecules;

b. By absorption of donor emission by the acceptor; this is a long-range transfer;

c. By a so-called resonance interaction (Forster Mechanism); this takes place over several molecular diameters, and is attributed to a dipole-dipole interaction.

Process "a" is a diffusion controlled phenomenon, and its limiting rate in a given solvent is known. Process "b" may be avoided if the system studied is such that the donor emission does not coincide with a region of appreciable absorption by the acceptor molecule. The problem of differentiation between processes "a" and "c" amounts to determining whether or not the measured rate of the process

$$D^* + A \longrightarrow D + A^*$$

is larger than that which can be computed on the assumption that every encounter of the excited donor D* with the unexcited acceptor A results in transfer. If either the donor or the acceptor is luminescent under the conditions of observation, the transfer process may be conveniently followed by measuring either the quenching of donor luminescence by the acceptor or the intensity of acceptor emission as a function of donor concentration; these two processes

should occur at the same rate.

A detailed analysis of quenching and sensitization processes such as mentioned here does not yield explicitly the rate of the energy transfer process; however, this rate can be obtained from the measurements if the lifetime of the excited donor is known under the conditions of the experiment.

For this investigation, biacetyl was used as the acceptor molecule. The donors chosen were naphthalene, benzene and acetone. For each pair of Donor-Acceptor, both the sensitization of the singlet state fluorescence of biacetyl and the quenching of donor singlet state emission by biacetyl were measured in aerated cyclohexane solution at 25°C. The results indicate that the transfer process proceeds at a rate consistent with a diffusion controlled mechanism such as "a".

Details of this work were presented at the 1961 International Conference on Luminescence held at the New York University 9-11 October 1961.

An interesting by-product of the research is a study of the photo-oxidation of biacetyl in solutions. In the investigation reported above, the biacetyl fluorescence signal as a function of wave length was recorded with a spectrophotofluorimeter. To ensure that no photochemical change is promoted by the light used to excite the fluorescence, the signal spectrum of a given solution was recorded two or three times in succession under the same conditions. In aerated solutions of biacetyl in cyclohexane, no change in fluorescence signal was observed, but when aerated water was used as a solvent it was found that after a few minutes a strong green luminescence appeared, the intensity of which increases with time of irradiation, whereas the original biacetyl fluorescence decreases by about 20%. This time dependent green luminescence is almost identical with the published phosphorescence spectrum of biacetyl exhibited by deoxygenated solutions.

The increase in intensity of phosphorescence with time can be attributed to the photochemical consumption of oxygen which quenches the emission. The 20% decrease in fluorescence indicates a simultaneous consumption of biacetyl. From the known concentration of oxygen dissolved in air-saturated water (2.5×10^{-4}M at 25°C) and the observation of the decrease in fluorescence with time, it is possible to show that a photo-oxidation alone probably cannot account for the consumption of biacetyl in this reaction. Some other process in which oxygen is not used up must also be involved. Such a process could be a photolytic hydrolysis producing acetic acid acetaldehyde, although further investigation would be required to verify this point. Actually, the photochemical reactions of biacetyl in solution appear to depend both on the nature of the solvent and on the concentration of the biacetyl, but there are no clear kinetic investigations on the subject. The observations reported here will be submitted in greater detail for journal publication.

Pattern Classification *technique*

Computer and Mathematical Sciences Laboratory, AFCRL

Pattern classification is a finely developed attribute of human intelligence. We recognize the letter A, for example, in an infinite variety of sizes and forms. We even recognize an A when it isn't there, as when inadvertently omitted from a word and reinserted sometimes subconsciously by the reader.

Present machines are far less adept at pattern classification. The problem is highly complex, and much research is being devoted to it. This research grows out of the obvious need for machines that can read and act on printed material -- whether this material is a Russian document to be translated by machine, or a mathematical formula.

Most of the approaches to the problem require sophisticated computer programs and circuitry. A popular approach is one which catalogues letters and numbers by their loops, angles, open ends, and so on. Herbert Glucksman of AFCRL has described a relatively simple technique for pattern classification. Patterns can be classified rapidly and without the need for elaborate equipment. Glucksman has designed the logic needed for the pattern classification scheme. He has called the scheme a "parapropagation pattern classifier."

Several operations are performed on each letter. First, the classifier places the particular letter being classified into one of two major classes. Next, the classifier analyzes it for its subclass. In this manner, through successive subclasses, the classifier narrows down the range of possible classifications until the letter is identified. A particular letter may be analyzed through as many as eight subdivisions before it is properly classified.

The classifier consists of an array, or grid, of identical cells. Each of the cells can exist in one of two states, zero (the original state), or one. The cells are connected in such a way that we can propagate a change to the one state across the array from the right, from the left, downward from the top, or upward from the bottom.

We also project a two-dimensional pattern on the array, e.g., by illumination. When we propagate the change of state inward toward the illuminated cells from any one of the four borders of the array, the illuminated cells block further propagation. We can

conceive of the illuminated pattern as casting a shadow composed of residual zero-state cells.

After a programed sequence of propagation commands, the field is tested to determine the number of cells still in the zero state. This residue depends on the pattern and on the sequence of propagation commands. It can be readily seen that, if we propagate from the left and from the top only, the residual number of zero-state cells will usually be quite different from the pattern derived by propagating from the right and from the bottom. By a proper sequence of commands, the classifier may also derive from the original pattern a new pattern also capable of blocking propagations. Tests are then conducted on the derived pattern, and further classification of the original pattern is made on the basis of these tests.

The construction of the parapropagation pattern classifier can be done with present-day advanced technology. The classifier can incorporate adjustable programing for various classification requirements.

high resolution antenna

Electromagnetic Radiation Laboratory, AFCRL

The most direct approach to improving the resolution (or sensitivity) of an antenna is to increase the size. Where high resolution is desired, as in the case of missile detection and radio astronomy, we find the giant BMEWS antennas and a great variety of huge radio telescopes.

But there is a practical limit to the size of solid reflectors. As the size of dish-type reflectors increases, costs and engineering problems increase disproportionately. The antenna designer is confronted with these facts when he considers antennas that will improve satellite and missile detection and communication with deep space probes. The problem then is to find an economical means for constructing large aperture antennas, and this, in turn, implies a departure from conventional dish-type reflectors.

Allan Schell of AFCRL has recently described a high resolution antenna that can be built at a fraction of the cost of a dish antenna of comparable resolution. The antenna described by Schell

will have an effective aperture diameter of 2400 feet, yielding a beamwidth of one minute of arc at L Band. (By comparison, the 1000 ft. Arecibo radio telescope now under construction will have a beamwidth of 10 minutes of arc.) The antenna will consist of 7000 flat reflecting plates, each about 20 feet square. When viewed from above, the array of plates appears as a giant clover leaf pattern. In the center of this clover leaf pattern is an 800 ft. tower for the antenna feed.

The plates making up the petals of the clover leaf pattern are arranged in concentric rows. Each of the plates is individually positioned and oriented to redirect radiation arriving from a particular direction of the focus -- that is, to the feed mechanism on the 800 ft. tower. It is possible to scan the antenna over a 90 degree cone -- 45 degrees in all directions from azimuth. A central computing unit would be used to determine the adjustments of each plate for a particular direction and wave length of radiation.

In constructing such an antenna, the initial placement of the plates would be relatively unimportant provided general rules are observed, because each plate can be adjusted to have the proper path length to the focus. The adjustability of the plates permits operation over a wide frequency range of 200 to 2000 MCPS and rapid and flexible beam steering. The use of a large number of identical components allows the antenna to be constructed by mass production techniques. The antenna can tolerate the malfunction of a number of the plate-orientation mechanisms without destroying the usefulness of the antenna.

Modifications in the aperture design, such as increasing or decreasing the size, are relatively simple. Depending on the desired size of the antenna, additional plates can be added. Thus there is a simple linear increase in cost as the aperture size increases.

A model of the antenna is now under construction at AFCRL's Strawberry Hill field site in Concord, Massachusetts. It will have 220 reflecting plates, each about five feet square. The tower will be 100 feet high. Tests of most interest to be conducted using the model will be measurements of noise temperature of the antenna, since a significant amount of the ground beneath the plates is seen by the feed. Several methods for minimizing the effect of the ground upon the temperature noise of the antenna will be investigated using the model. Optimum spacing of the individual plates will also be investigated.

ON COMMUNICATION OF *information*

ROWENA SWANSON, Directorate of Information Sciences, AFOSR

The communication of information to the person who needs it at the time he needs it inevitably results in the advancement of his intellectual pursuits. That this is becoming recognized is evidenced by the mushrooming number of information centers, libraries, and other forms of organized printed collections under government, industry, and university sponsorship. One of the most ambitious of these activities is ASTIA - the Armed Services Technical Information Agency - sponsored by the Department of Defense, under the management of the United States Air Force, and charged with the responsibility of being the depository for the documents issued under the DOD research and development program. The ASTIA mission to collect and disseminate this massive quantity of information to those in need of it in in-house military organizations and in DOD contract operations has been impeded by the usual shortages, not the least of them being the manpower shortage.

The miracle of Arlington Hall Station, Virginia, where ASTIA is now physically located, is the recent appearance, at monthly and more frequent intervals, of manpower not on the ASTIA payroll working at and for ASTIA in an exercise to improve ASTIA's performance as a communication link. The exercise, nominally termed the ASTIA Thesaurus Revision Meetings, has attracted representatives of public and private organizations concerned with information processing. These persons have become participants in working groups to study and develop methods of improving various aspects of the ASTIA information storage and retrieval system.

This reporter is associated with one of these working groups. Designated the working group on Field and Group Arrangements, this unit is attempting to establish a basic hierarchical classification for the scope of subjects encompassed by the ASTIA collection. Potential uses of the classification range from a guide for the distribution of reports according to a rough-cut subject need-to-know to a means for integrating the ASTIA subject index with the indexes to other files at a generalized subject level. The group is currently establishing the first hierarchical level with projections for one or two sublevels.

The goals of the seven other working groups are indicated by their titles: Group 1 on Scope Notes, Synonyms, and Indexing

Negative and Positive Statements; Group 3 on Combined Words, Selectivity, Modifiers and Role Indicators, Consistency of Descriptor Assignment, and Pyramiding; Group 4 on Glossary of Terms; Group 5 on Identifiers; Group 6 on Format; Group 7 on Compatibility with Other Thesauri; and Group 8 on Chemistry.

In conjunction with these efforts is the daily work of the revision of the ASTIA Thesaurus itself. The first edition, issued in May 1960, represented a major step forward in streamlining the terminology by which users of the ASTIA collection could gain access to information. The compilation was largely the product of the intellectual labor of ASTIA personnel. The revision exercise has been proceeding on a time schedule by subject, and is being benefited by the intellectual contributions of experts and users in the particular disciplines. The Engineers Joint Council has, moreover, seen fit to support Mr. Eugene Wall to guide the revision, and has furnished additional support for other participation in the revision.

Is this a report of a modern-day demonstration of altruism? Yes, up to a point. But it is also an indication of the awareness of many organizations whose staffs are in vital need of the information which ASTIA services could provide that across-the-board cooperation is one key to insuring satisfaction of their needs. A Thesaurus usable both at ASTIA in its totality and at individual laboratories in particular subdisciplines can speed search times and provide more meaningful, less redundant and noisy answers to reference questions.

How did this venture get started? Through the inspiration and leadership of the new commander of ASTIA, Colonel James O. Vann, an ASTIA user himself during his previous tour of duty with the Office of Aerospace Research (formerly the Air Force Research Division of ARDC). Colonel Vann has outlined a program for expanding and improving the ASTIA collection and services to the greatest extent possible. This is a report of one aspect of that program.

The exercise will not be finished with the publication of a revised Thesaurus and reports of the working groups. The next revision is already being considered. Why? Because scientific research and technological development are not static. The intellectual genius of man synthesizes from information new combinations, new processes, new products. These are described by new terminology and the old must be re-examined and regrouped.

Four fifths of the scientists who have ever lived are alive today, at work exploring into the unknown. It is for good reason, then, that the exercise started at ASTIA attracted such wide interest and participation. The closer we get to a coordinated communications structure from which our scientists can satisfy their particular information needs, the faster our national progress can be.

AFCRL CRYSTAL PHYSICS

Electronic Materials Sciences Laboratory, AFCRL

In February,AFCRL occupied the most complete research facility for growing single crystal materials in the country.The new Crystal Physics Building,when fully equipped,will permit AFCRL to grow all types of crystals having potential application to solid state devices.

Single crystal materials will be grown in the new laboratory by a great diversity of means -- from solution, from melts, from vapors, at low pressures and at extreme high pressures. Crystals of particular interest to AFCRL at the present time are silicon carbide, silicon, rare earth garnet-structured materials, diamonds, rubies, rutiles fluorides, tungstates, and so on.

William Field, who heads the AFCRL crystallography research program, emphasizes the fact that research in the new facility will be primarily concerned with the processes of crystal growth rather than with the growth of crystals for specific experimental components. Research will focus on increased crystal size, greater crystal purity, and reducing imperfections within the crystal.

Many of the crystal-growing equipments in the new facility are unique. Within the next few months, a special furnace for growing silicon carbide crystals of relatively large size and high purity will be placed in operation. This complex furnace, designed by Dr. Juris Smiltens of AFCRL, has been under construction for almost two years. The facility will also house AFCRL's high-pressure apparatus, capable of growing diamonds, and specially designed verneuil furnaces for growing rubies and other materials.

The Crystal Physics Building itself, located at L. G. Hanscom Field, Bedford, Massachusetts, has three separate wings. Certain kinds of crystal are grown under conditions that might constitute a physical danger to research personnel. Thus one of the wings of the building has specially reinforced concrete walls, and special shielding behind which the personnel may monitor the crystal growing apparatus. A second wing of the building was designed to permit the growth of crystals in a vibration- and contamination-free environment. In some cases, the slight vibration of the building during

the growth process can affect the perfection of the crystal. The third wing will house equipment for cutting and polishing crystals in proper form for analysis or for testing in experimental devices.

Because many of the research equipments within the new building can be found at no other laboratory in the country, AFCRL plans to permit certain selected contractor and university personnel to conduct experiments on a cooperative basis within the facility. If appropriate arrangements can be made, AFCRL will teach qualified outside research groups to grow special crystals. In some instances, AFCRL may undertake cooperative research programs with outside groups within the facilities. It is hoped that these proposed programs with qualified outside groups will result in additional research valuable to the Air Force.

PHOTO CELL

for intense, high speed light pulses

PETER BLETZINGER, Plasma Physics Research Branch, ARL

Recent advances in high-speed pulse techniques have made it necessary to extend these techniques into the field of light sensors. Kerr Cells now allow the generation of light pulses as short as five nanoseconds, or they are used to modulate light sources with microwave frequencies. Lasers produce high-intensity light pulses which, due to the mechanics of their generation under some conditions, consist of a series of short bursts of pulses. Plasma research working with pulsed discharges requires extremely accurate synchronization of luminous events like pinched discharges, instabilities and shock waves with the diagnostic equipment being used, in order to get meaningful results. All these events require a sensor which can resolve time intervals shorter than 10^{-9} seconds. Presently available sensors are inadequate; photomultipliers, due to their internal spread in electron transit time, cannot resolve these short intervals; and standard photocells, due to their design, are not usable at very high frequencies; in addition, their sensitivity and ability to measure very high intensity pulses is limited.

In order to meet the requirements of a high-speed light sensor, a photocell with the following features has been designed and investigated:

The photocell has to be an integral part of a coaxial, impedance matched system which includes the traveling wave oscilloscope used

as an indicator. Since the characteristic impedances involved are rather low, the photocell has to deliver large currents in order to produce voltages big enough for accurate display. This, in turn, requires that the cell has a large cathode area to produce this current, allow the application of high anode voltages in order to preserve the linearity, and has a voltage source incorporated into the design so that the large currents are instantly available with no delay through long inductive leads. Since the photocell is often used in close neighborhood to devices which produce large amounts of electromagnetic radiation, it should be completely shielded electrically without decreasing the light input intensity appreciably. In order to make the use of high anode voltages possible, a low dark current is required. This is achieved by a relatively smooth cathode surface with a low field emission, the main contribution to dark current in this mode of operation.

Rather than go to the extent of fabricating a phototube ourselves, a tube developed by IT&T for service with a scintillator was selected. It has a planar construction having a mesh anode attached to the faceplate and a circular planar cesium antimonide cathode on a metal substrate. The planar arrangement, in connection with the high voltages used, is another important factor in high-speed pulse measurements. It assures that the electron emitted from the cathode have as uniform a transit time to the anode as possible. Fast pulse risetimes are not "smeared out" by electrons emitted at the same instant but arriving at the anode at different times. Other desirable features include a very low dark current of less than 10^{-9} amperes at an anode voltage of 4 kilovolt, and a cathode of low internal resistance, capable of delivering the large emission currents with no internal losses.

We then fabricated a housing for this tube designed to fulfill all the requirements mentioned. It is coaxial and the characteristic impedance level for all parts including the photocell is kept constant. To achieve an impedance match with the signal cable over a very wide frequency range, a ceramic disc thin film resistor has been used as load resistance. The electrical shielding has been accomplished by grounding the anode mesh with a number of ceramic capacitors attached to the periphery of the photocell. These capacitors also provide the very large pulse currents which this photocell is capable of delivering.

The design of such a high-speed photocell would not be complete without some more detailed investigations of its characteristics. In particular, the limits of linear amplitude response and the limits of its high-frequency response must be considered.

The linear relation between light flux on the photocathode and electron current emitted has its limitations in the fatigue of the

cathode -- resulting from excessive currents and also in the formation of a space charge by the electrons emitted. The cathode shows fatigue or reduction of sensitivity when current densities in excess of 1 uA/cm^2 are emitted. It has been shown, however, that this applies for average values only, and much higher currents can be drawn under pulsed conditions providing the average rating is not exceeded. We have been able to draw currents as high as 0.7 Amperes/cm^2 without any damage to the photocathode. As an interesting side note, this current density was achieved when the output energy of this photocell exceeded 3 kilowatts!

Electron space charge will have the same effect on the characteristics of the photocell as it has on a vacuum tube with thermionic cathode. With no space charge present, the electric field, and therefore the acceleration of the electrons between cathode and anode, is constant. All electrons emitted will reach the anode. The current, therefore, is exactly proportional to the cathode emission current which, in turn, is proportional to the light flux on the photocathode. With a large enough number of electrons emitted, a space charge is formed, the accelerating electric field in front of the cathode is reduced to zero, and emission current is no longer determined by the cathode emission but solely by the anode voltage according to the well-known Child's law. Also, the electron transit time is exactly 1.5 times as large as without space charge present.

There is a gradual transition between these two regions, and it is impossible to recognize from the measured pulse shape if it is an exact replica of the light pulse or if space charges distort the electrical pulse. A set of characteristic curves taken for this photocell under pulsed conditions allows us to determine if we are working in the region free of space charge. The characteristics are taken for a set of illumination levels up to approximately 300,000 lumens with varying anode voltages. It has been established that this photocell is linear and free of space charge effects up to a current of 8 amperes.

We have not been able to establish any limits for the frequency response for this photocell as yet. Since the emission of electrons upon the absorption of light quantum is practically instantaneous, a frequency limit is only given by the mechanical configuration of the photocell and its circuitry but, by careful design of this high-speed cell, no limitations should exist with frequencies up to the Gigacycle range. Measurements of Kerr cell pulses for the first time have shown accurate detail down to the shortest exposure times and, above all, the results are perfectly reliable and repeatable.

THEORETICAL RESEARCH ON *shock waves*

DR. BRUNO J. MANZ, Mathematics Division, Directorate of Research Analyses, AFOSR

Shock waves involve complicated physical phenomena, such as heat conduction, internal friction, and many others. This makes theory so difficult that only under drastic idealizations is a rigorous mathematical treatment possible.

The school case of shock wave physics is the one-dimensional wave with steady states everywhere and with homogeneous states far to the left and to the right of the wave center. This case has been studied since the days of the great Bernhard Riemann. It is governed by a differential equation which cannot be solved generally. This means it cannot be solved for every value of two decisive parameters which are called Mach number and Prandtl number. The first parameter measures the flow velocity in units of the velocity of sound. The second one weighs the influence of internal friction and heat conduction against each other.

At present, there are three "exact" solutions for special values of the Prandtl number: The Rankine solution (1870), the Rayleigh solution (1910) and the R. Becker solution (1922). At the Directorate of Research Analyses, a further exact solution has been found holding for the case in which Mach number and Prandtl number are simple functions of the ratio of specific heats which itself may lie somewhere in a realistic range. Furthermore, an approximate solution which holds for any Prandtl number and ratio of specific heats and for Mach numbers under certain minor restrictions was established.

A few comparisons have been made between the new exact solution and the approximate solution. In general, the agreement is close; however, it varies according to the special case. In cases with a relatively low Mach number (1.7), the deviation is smaller than 2%; for higher Mach numbers (2.4), it is 2.7%.

The results will soon be submitted for publication.

GPO 927294

Notice to Our Readers

Requests for further information, copies of detailed reports, etc. should be directed to the individual or laboratory of origin.

Addresses are as follows:

- For reports originating within Air Force Cambridge Research Laboratories:

  AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
  Laurence G. Hanscom Field
  Bedford, Massachusetts

- For reports originating within Aeronautical Research Laboratory:

  AERONAUTICAL RESEARCH LABORATORIES
  Wright-Patterson Air Force Base, Ohio

- For reports originating within Air Force Office of Scientific Research:

  AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
  Tempo D Building
  4th and Independence Ave., S.W.
  Washington 25, D.C.

RESEARCH REVIEW is published by the Office of Information (RREI), Office of Aerospace Research, USAF, Washington 25, D. C. The frequency of this publication will be determined solely on the basis of the availability of significant material to report. The objective is to make a positive contribution to the exchange of information about Air Force sponsored and conducted basic research activities.